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NEW NEARCTIC CRANE-FLIES (TIPULIDAE, DIPTERA), PART XXIII.

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The preceding part under this general title was published in 1945 (Can. Ent., 76:217-222). In the present paper I am describing certain species of unusual interest that were collected and sent to me by Messrs. Aitken, Bohart, Degener, Melander and the late Millard C. Van Duzee, to all of whom I express my sincere thanks and appreciation for this aid. Except where stated to the contrary in the text, the types of the novelties are preserved in my personal collection.

Limonia (Dicranomyia) melanderi n. sp.

General coloration brownish yellow, the praescutum with three darker stripes; rostrum yellow; antennae black throughout; head above dark gray; halteres elongate, knobs darkened; legs obscure yellow, terminal tarsal segments blackened; wings subhyaline, stigma not indicated; Sc_1 very long; male hypopygium with the tergite transverse-oval, its posterior border not or scarcely emarginate; basistyle with a complex ventromesal lobe; ventral dististyle about equal in total area to the basistyle, the rostral prolongation bearing a long slender rod on the outer margin, immediately basad of the two rostral spines; gonapophyses with mesal-apical lobe elongate, sinuous; aedeagus elongate, before tip with pale bulbous setoid outgrowths.

Male. Length about 5.8-6 mm.; wing 6-6.5 mm.

Female. Length about 6.5 mm.; wing 7 mm.

Rostrum yellow; palpi black. Antennae black throughout; flagellar segments oval, the outer ones more elongate; terminal segment long, a little exceeding the penultimate. Head above dark gray, paling to brownish yellow beneath; anterior vertex (male) wide, nearly four times the diameter of the scape.

Pronotum infuscated medially, paling to yellow on the sides. Mesonotal praescutum with the ground obscure yellow, with three darker stripes, the broader median stripe darker in front; scutal lobes scarcely darkened, median region narrowly pruinose; scutellum behind obscure yellow; mediotergite pale brown, sparsely pruinose. Pleura yellow, the posterior sclerites, including likewise the pleurotergite, sparsely pruinose. Halteres elongate, stem pale, knob darkened. Legs with the coxae and trochanters pale yellow; remainder of legs obscure yellow, the terminal tarsal segments blackened. Wings subhyaline, the prearcular and costal fields a trifle more yellowed; stigma not or scarcely indicated; veins brown, paler in the more brightened fields. Venation: Sc_1 ending just before origin of *Rs*, Sc_2 far from its tip, Sc_1 thus very long, exceeding *Rs;* cell 1*st* M_2 about as long as vein M_4; *m-cu* at or a short distance before the fork of *M*.

Abdominal tergites dark brown, basal sternites yellow, the outer ones darkened; hypopygium yellow. Male hypopygium large; tergite transverse-oval in outline, its caudal margin not or scarcely emarginate. Basistyle of moderate size, with a large and conspicuous ventro-mesal lobe; this latter generally parallel-sided, at its apex divided into two lobes, the broader one with long, very delicate setae and fewer long coarse bristles near the subacute apex; the smaller apical lobe is again split into an outer blackened spine and an inner fleshy lobule that is provided with very long coarse setae from prominent tubercles; face of style

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near base of lobes with a group of about 14 or 15 small blackened knobs. Dorsal dististyle a slender, strongly curved hook, its tip acute. Ventral dististyle nearly equal in its total area to the basistyle; body of style relatively small, with a large rounded secondary lobe near its base; rostral prolongation very large and complex, more sclerotized than the remainder of style; base stout, the outer half or less more narrowed, the usual two spines at the base of the narrowed portion on outer margin; immediately basad of these spines a long, slender branch that is only a little shorter than the entire prolongation and approximately one-half as long as the dorsal dististyle. Gonapophyses with mesal-apical lobe long and narrow, very strongly sinuous, its tip narrowly obtuse. Aedeagus very long, near its outer end with numerous pale setoid extensions that are enlarged at their tips into small pale bulbs.

Habitat: Idaho (Boundary County).

Holotype: ♂, Lookout Mt., Priest Lake, August 20, 1920 (A. L. Melander); Melander Collection. *Allotopotype*: ♀. *Paratopotypes*: 2 ♂♂.

I take great pleasure in naming this very distinct fly in honor of Dr. Axel Leonard Melander. Among the now relatively numerous described species of the subgenus that have the male hypopygium complex, the present fly agrees with *Limonia* (*Dicranomyia*) *particeps* (Doane) in certain details of coloration and venation. The male sex of this latter fly is still not known to me. Doane mentions the hypopygium only in general terms but one of these, the enlarged ventral dististyles as compared with the basistyles, definitely disagrees with the present fly. There are now known rather numerous regional species that have unusually complicated hypopygia, all of these differing among themselves in the details of structure of this organ.

Pedicia (Tricyphona) macrophallus n. sp.

Allied to *constans*; general coloration of thorax fulvous yellow, the posterior sclerites faintly pruinose; antennae yellow, the outer segments slightly darkened; head dark brownish gray; legs yellow, the tips of the femora brownish black, of the tibiae less conspicuously so; wings yellowish subhyaline, the prearcular and costal borders pale yellowish brown, this color continued to the wing tip; $R_2+_3+_4$ subequal in length to *r-m*; cell 1*st* M_2 long; abdominal tergites brownish yellow, trivittate with dark brown; male hypopygium unusually large; basistyle on mesal aspect of dorsal face with a compact group of four or five blackened spinous setae; dististyle deeply forked, the lateral branch longer and stronger; aedeagus long and powerful, bent strongly dorsad.

Male. Length about 15 mm.; wing 12.5 mm.

Rostrum dark brown; palpi black. Antennae 16-segmented; yellow, the outer segments slightly darkened. Head above dark brownish gray, paler brown on occiput; vertical tubercle weakly developed.

Pronotum yellow, narrowly darkened in front. Mesonotum almost uniform fulvous yellow, the surface more or less pruinose, more heavily so on the posterior sclerites. Pleura yellow. Halteres yellow, knobs weakly darkened. Legs with coxae fulvous yellow; trochanters yellow; femora yellow, the tips broadly and conspicuously brownish black, a very little more extensive on the posterior legs; tibiae yellow, the tips more narrowly blackened; tarsi yellow, the outer segments black. Wings yellowish subhyaline, prearcular region and costal border pale yellowish brown, the latter color continued to the wing tip, behind not passing caudad of vein *R*; a tiny darker brown dot over R_2 but with no other darkenings on wing; veins light brown, *Cu* more yellowed, particularly at base. Venation: *Rs* very strongly angulated and spurred at origin; *r-m* before fork of *Rs*; $R_2+_3+_4$ subequal in length to *r-m*; R_1+_2 about one-half longer than R_2; cell 1*st* M_2 long; *m* beyond fork of M_1+_2; *m-cu* close to the fork of *M*.

Abdominal tergites brownish yellow, narrowly trivittate with dark brown,

the median darkening becoming more distinct behind but interrupted by narrow yellow posterior borders to the segments; all stripes becoming broader and more conspicuous on outer segments; sternites yellow, clearer at base of abdomen; outer segments and hypopygium chiefly dark brown. Male hypopygium unusually large; tergite strongly narrowed outwardly, the caudal border of the narrowed portion broadly emarginate; no lateral tergal lobes. Basistyle on mesal aspect of ventral face near the cephalic end produced into a small hairy lobe, its setae much exceeding the length of the lobe itself; on dorsal aspect of mesal face a group of four or five blackened peg-like spinous setae; apex of basistyle produced into a flattened lobe, its tip with blackened peg-like spines; interbase a strong, gently sinuous, simple rod, the tip obtuse. Dististyle deeply forked, the stem short and stout, the axial branch slender, straight, its tip obtuse; lateral branch longer and stronger, at apex terminating in a spinous point; on stem at fork with a single further blackened spine. Aedeagus long and powerful, bent strongly dorsad, its tip weakly expanded, on dorsal face at near midlength with a projecting lobe.

Habitat: Oregon (Marion County).

Holotype: ♂, Silver Falls State Park, June 23, 1939 (T. H. G. Aitken and George Bohart).

Pedicia (*Tricyphona*) *macrophallus* is very different from all other western Nearctic species of the subgenus that center about *P.* (*T.*) *constans* (Doane), including also *P.* (*T.*) *bicomata* Alexander and *P.* (*T.*) *simplicistyla* (Alexander). The large, complicated male hypopygium is entirely distinctive of the species.

Pedicia (Tricyphona) fulvicolor n. sp.

Allied to *rubiginosa*; size large (wing, female, over 12 mm.). General coloration of mesonotal praescutum reddish, weakly overcast by a gray pruinosity; antennae 17-segmented; halteres and legs yellow, the outer tarsal segments more infuscated; wings with a strong fulvous suffusion, the coastal region and wing tip more saturated; the stigma not differentiated; cell R_3 sessile; cell M_2 open by the atrophy of *m*.

Female. Length about 11 mm.; wing 12.3 mm.; antenna about 1.8 mm.

Rostrum gray; palpi black. Antennae 17-segmented, relatively elongate; scape dark brown, sparsely pruinose; pedicel and proximal segments of flagellum obscure brownish yellow, the outer segments passing into dark brown; flagellar segments subcylindrical; basal flagellar segment formed by an incomplete fusion of two short units, if completely divided totalling 18 segments. Head uniformly gray.

Pronotum and mesonotum chiefly reddish, weakly overcast by a gray pruinosity; praescutal stripes scarcely differentiated, the lateral borders more pruinose; posterior sclerites of notum darker brown. Pleura brownish gray; dorsopleural membrane light yellow. Halteres relatively long, yellow. Legs with fore coxae yellow, the remaining coxae more reddish brown, darker basally; trochanters yellow; remainder of legs yellow, the outer tarsal segments more infuscated. Wings with a strong fulvous suffusion, the costal region and wing tip more saturated, the stigma not differentiated; veins yellow. Venation: *Rs* relatively short, about twice *m-cu;* cell R_3 sessile, cell R_4 very short petiolate, vein R_4 thus arising almost at the end of *Rs;* R_{1+2} shorter than R_2; cell M_2 open by the atrophy of *m*; *m-cu* more than one-half its length beyond the fork of *M*.

Abdominal tergites yellowish brown, the latter color possibly caused by discoloration; posterior borders of segments very narrowly yellow; sternites clearer yellow. Ovipositor with the cerci strongly upcurved, their tips subacute.

Habitat: Idaho (Latah County).

Holotype: ♀, Moscow Mountain, September 10, 1922 (A. L. Melander).

This conspicuous fly seems to be well distinguished from its only close Nearctic ally, *Pedicia* (*Tricyphona*) *rubiginosa* (Alexander), of British Columbia and Alberta, by the much larger size. The wing of the female is more than one-half longer than in the comparable sex of *rubiginosa* and has more than twice the area. The elongate 17-segmented antennae similarly provide a specific distinction and it is believed that the male sex, when discovered, will furnish still further characters in the hypopygium.

Phyllolabis sequoiensis n. sp.

Size large (wing, female, 8 mm. or over); general coloration of head and thorax dark gray; antennae brownish black throughout; legs obscure brownish yellow, the outer tarsal segments black; wings with a brownish tinge, the stigma very pale yellowish brown, inconspicuous; ovipositor with cerci relatively broad, at apex suddenly narrowed into a cultriform blade, the lower margin with from eight to ten teeth, of which the outermost is the largest.

Female. Length about 9 - 9.5 mm.; wing 8 - 9 mm.; antenna about 2 mm.

Rostrum gray pruinose; palpi black. Antennae brownish black throughout, the scape pruinose; antennae relatively long; basal flagellar segments subcylindrical, the outer ones gradually decreasing in size and finally passing into long-oval; longest verticils shorter than the segments. Head gray; anterior vertex nearly three times the diameter of the scape.

Thorax dark gray, without evident pattern; dorsopleural membrane lighter gray. Halteres with stem obscure whitish, the knob weakly darkened. Legs with fore coxae blackened, pruinose, the apex yellow; remaining coxae and all trochanters yellow; remainder of legs obscure brownish yellow, the outer tarsal segments black. Wings ample, with a marked brownish tinge, the prearcular and costal fields more yellowed; stigma very pale yellowish brown, only slightly differentiated from the ground; veins brown, more yellowed in the brightened fields. Costal border not expanded near the sigma, as in *lagganensis*. Venation: Sc_1 ending about opposite one-fifth to one-third the length of R_{2+3+4}, Sc_2 a short distance from its tip; R_{2+3+4} elongate, subequal to or a little shorter than the nearly equal Rs and R_3; *m-cu* at or a short distance before the fork of M_{3+4}.

Abdominal tergites brown, the sternites obscure yellow or brownish yellow, with blackish pruinose posterior borders to produce a ringed appearance, these annuli becoming more extensive on outer segments. Ovipositor with cerci relatively broad, at apex suddenly narrowed into a cultriform or obtuse blade, the lower margin with 8 to 10 teeth, the outermost largest, the others becoming smaller and more crowded. In *encausta*, the tip of each cercus is less abruptly narrowed and the marginal teeth are more numerous and distinct.

Habitat: California (Tulare County).

Holotype: ♀, Sequoia National Park, June 6-8, 1942 (Otto Degener).

Paratopotypes: 5 ♀ ♀.

Phyllolabis sequoiensis is entirely distinct from all other known species, evidently being most nearly related to *P. encausta* Osten Sacken. This latter fly differs conspicuously in the slightly patterned wings, including a dark brown stigma, and in the nature of the serrations along the ventral margins of the cerci.

In our fauna, *Phyllolabis* comprises a rather extensive group of essentially far western species, all differing among themselves in a wealth of characters in the male hypopygium, with lesser distinctions in the structure of the ovipositor. Of these species, the present fly and *P. encausta* have the cerci most conspicuously serrate, most of the others having this organ slender and with smooth margins. It is of interest to note that a closely parallel condition of the ovipositor is found

in the evidently unrelated genus *Aphrophila* Edwards, with several species in New Zealand and southern Chile, and that all of these latter species whose immature stages are known are strictly aquatic, almost as in the Blepharoceridae. Whether this parallelism of habits will be found to occur in *Phyllolabis* is unknown. The geographical distribution of *Phyllolabis* throughout its range is most noteworthy. A very few species occur in northern Europe, with a marked concentration of forms in the Himalayan region of India and southwestern China, though with none occurring in Japan or coastal eastern Asia. In North America, most of the species are restricted to the Pacific states and provinces, extending from British Columbia and Alberta, south to the Mexican border in southern California, with an evident concentration of forms in the Californian and Mohavian biotic provinces. A single species, *P. lagganensis* Alexander, has an unusually extensive range in the central and northern Rocky Mountains, thence eastward, recurring on the highest mountains of northern New England (New Hampshire; Vermont: Mt. Mansfield).

Phyllolabis meridionalis n. sp.

Size relatively small (wing, male, 6.5 mm. or less); general coloration gray; antennae dark throughout; wings with a pale brownish suffusion, the stigma elongate but very pale; no darkened seam along vein *Cu*; R_{2+3+4} elongate, subequal to *Rs*; male hypopygium with the inner apical angle of basistyle produced into a small pale spinous point; dististyle bilobed, the inner lobe broadly and obtusely rounded, the outer one produced into a subacute point.

Male. Length about 5.5-6 mm.; wing 6-6.5 mm.

Rostrum gray; palpi brownish black. Antennae black throughout, the scape more or less pruinose; flagellar segments subcylindrical. Head brownish gray, somewhat clearer gray along the orbits; anterior vertex approximately four times as wide as the diameter of the scape.

Pronotum brownish gray. Mesonotum dark gray, the praescutum with an ill-defined more brownish median stripe; pseudosutural foveae short-oval in outline; dorsopleural membrane buffy brown. Halteres with stem pale, knobs broken. Legs with coxae brown, gray pruinose; trochanters obscure brownish yellow; remainder of legs light brown, the outer tarsal segments brownish black. Wings with a pale brownish suffusion, the prearcular field slightly yellowed; stigma much paler and more elongate than in *claviger*, inconspicuous; no darkened seam along vein *Cu* as in *claviger*; veins brown, yellow in the prearcular field. Venation: R_{2+3+4} elongate, subequal to or nearly as long as *Rs*; veins R_3 and R_4 divergent, so cell R_3 at margin is equal to or more extensive than cell R_2.

Abdominal tergites dark brown, the sternites much paler, obscure brownish yellow; hypopygium with the styli brownish yellow, the appendage of the ninth sternite still paler yellow. Male hypopygium most similar to that of *claviger* but differing in important details, particularly of the basistyle and dististyle. Bastistyle with its apex broad, the inner apical angle produced into a small pale spinous point, the outer lateral angle extended into a conspicuous setiferous lobe; pendulous lobe of basistyle bulbous at apex, the free caudal portion oval, the distal part densely short-setiferous, appearing more or less like a cap over the more nearly glabrous body of the lobe. Dististyle bilobed, the inner or caudal lobe broadly and obtusely rounded, the outer arm still broader, at its apex with the outer angle produced into a subacute point. Spines of gonapophyses appearing as relatively short, very slender, acute rods. Appendage of ninth sternite pale, slightly wider across base, the apical third with a deep median split, the lateral lobes obliquely truncate. In *claviger*, the outer apical angle of the basistyle is produced into a strong, dark-colored lobe, the fleshy setiferous lobe likewise differently formed. Dististyle a relatively simple blade, near the outer two-thirds bent at a right angle to the narrow obtuse tip.

Habitat: California (San Diego County).

Holotype: ♂, Alpine, April 10, 1915 (M. C. Van Duzee).

Paratopotype: 1 ♂, April 11, 1915. Further specimens in Van Duzee Collection under the name "*claviger* Osten Sacken".

I had earlier determined this species as being *Phyllolabis claviger* Osten Sacken but with ample material of the latter now available, there is no question of the distinctness of the present fly. The essential characters for the differentiation of the two species have been given in the above description. In life, this species was found to be associated with *Phyllolabis flavida* Alexander, one of the most isolated members of the entire genus.

Phyllolabis myriosticta n. sp.

General coloration dark plumbeous gray; wings whitish subhyaline, very heavily spotted and dotted with brown, the dots occurring in virtually all the cells and becoming more or less confluent; ovipositor with the cerci relatively slender, the ventral edge back from the apex microscopically toothed.

Female. Length about 7 mm.; wing 7.4 mm.

Rostrum and palpi black. Antennae with scape and pedicel dark brown, the former sparsely pruinose; flagellum obscure brownish yellow, the outer segments more infuscated; flagellar segments subcylindrical, broader just before the middle of their length and here with conspicuous verticils that are a little shorter than the segments; terminal segment subequal in length to the penultimate. Head dark gray, with dark-colored setae from brown setigerous punctures; anterior vertex a little less than three times the diameter of scape.

Pronotum brownish gray, the scutellum obscure brownish yellow. Mesothorax dark plumbeous gray, without pattern; pseudosutural foveae small, oval, black; dorsopleural membrane infuscated. Halteres with stem pale, particularly at base, knob infuscated. Legs with the coxae dark gray pruinose; trochanters yellowish brown to light brown; remainder of legs broken. Wings whitish subhyaline. very heavily spotted with dark brown and variegated with an abundance of paler brown dots in all the cells; the larger brown areas occur over arculus at origin of *Rs*; fork of *Sc*, continued backward over the anterior cord; extensive brown areas at tip of vein R_3 and over outer end of cell 1*st* M_2; the paler dots are so abundant as to be confluent in most of the cells, their total area subequal to or greater than that of the interspaces; the dots along the interspaces of the cephalic quarter of wing much more sparse but darker and with more clearly defined borders; veins brownish yellow in the ground areas, darker in the patterned fields. Venation: Sc_1 ending a short distance beyond level of fork of *Rs*, Sc_2 shortly before this fork; Rs angulated and short-spurred near origin; $R_2+_3+_4$ a trifle shorter than R_3; cell 1*st* M_2 about one-half of vein M_3 beyond it; *m-cu* at fork of M_3+_4.

Abdomen dark brown, sparsely pruinose. Ovipositor with cerci relatively slender, produced at apex into a small cultrate point, the ventral edge back from the tip for more than one-third the length with about eight or nine small obtuse denticles, the more basal ones becoming very low and ill-defined.

Habitat: California.

Holotype: ♀, Ortega Highway, March 28, 1935 (A. L. Melander).

Phyllolabis myriosticta is entirely different from all known species of the genus by the heavily patterned wings. All others have the wings unpatterned or virtually so, except for the stigmal darkening, when this is present. I am indebted to Mr. John L. Sperry and Dr. Melander for more explicit information as to the type locality of this fly. It is believed that the type was taken along the Ortega Highway close to the Riverside County-Orange County line, probably in Riverside County between Elsinore and San Juan Capistrano and perhaps at an altitude of about 2,000 feet.

CONDITIONS GOVERNING THE DISTRIBUTION OF INSECTS IN THE FREE ATMOSPHERE*

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INTRODUCTION

Insect collecting by aircraft (1) has shown that individuals of some species of insects attain heights of four or more kilometers above the earth (6). Upon consideration of the meteorological conditions within this vertical range, it would seem that the normal decrease with height of atmospheric pressure, temperature and humidity would bar flights to altitudes such as those at which specimens have been found. Conversely, certain atmospheric processes might act to carry insects inertly to such altitudes, possibly beyond the supposed limits of insect resistance to the first-named elements.

The first part of this series deals with some laboratory experiments to determine the effects of substantial decreases in air pressure, temperature and humidity upon certain common species of insects. Experimental environments were established, and all single or combined limiting, sterilizing or lethal factors were sought. Subsequent parts will be devoted to the consideration of the various types of atmospheric processes which might be considered suitable for vertical or horizontal distributions of insects in the light of the results obtained in Part I.

PART 1: ATMOSPHERIC PRESSURE, TEMPERATURE AND HUMIDITY

A vertical cross-section of the atmosphere shows that the normal environmental changes upward consist of decreases in the temperature, pressure and moisture-content of the air. The decrease in temperature is known as the "lapse rate", which is generally taken to average about 6.0 degrees Centigrade per kilometer, although there may be wide fluctuations from this average under actual conditions aloft.

In the experimental work, it was necessary to determine the effects of the decreases in the above primary factors, singly and combined, upon the insects under observation. Hence, conditions were varied to this end. It was assumed that any ascent would begin at sea-level. The sea-level conditions were established arbitrarily at a pressure of 1,000 millibars (where 1 mb. = 0.75 mm. = 0.0295 in. of mercury), a temperature of +24.0 degrees C. and a relative humidity of 60 per cent.

METHOD

There was available for the experimental work a pressure-temperature chamber of such a design that any desired combination of air pressure and temperature could be established and maintained as long as was required. This chamber was fan-equipped to avoid layering of the air. Humidity effects were tested in a different manner, mentioned later in the paper.

It was possible to observe the actions of the test-species during all stages of the experiments. The insects were usually placed in small cages, open to ventilation to guard against any serious lag in changing conditions. To determine whether inactive insects were actually responding to changes, or whether they were merely resting, a small door-bell buzzer, controlled outside the chamber, was attached to the containers under observation. With this device it was possible to vibrate the cages when it was impossible to open the chamber door.

The insects used in the experiments were all field-collected adults, so that the effect of adult age as a resistance factor had to be neglected. Only winged insects were used, which further limited the scope. Both sexes of a species were used, when obtainable, so that any possible sex differences in resistance might be determined. The species tested were divided into normally

*This paper is the first of a series that will appear in succeeding numbers of the *Canadian Entomologist*.

diurnal and normally crepuscular or nocturnal types, since the evaluation of their resistances might depend to a great extent upon the time of their normal activity. The species utilized are listed in Table I.

This list is intentionally brief, since it was not desired to establish a series of values of the limiting factors for a large number of species, but rather to determine, in representative species, the possible effects at higher altitudes of certain environmental conditions generally assumed to be injurious to most insects at the surface.

TABLE 1. List of species utilized.

Diurnal Species	Nocturnal Species
Homoptera	
Ceresa bubalus Fab.	*Cicadellidae (various spp.)
	*Cercopidae (various spp.)
Neuroptera	
	Chrysopa sp.
Coleoptera	
	Elateridae (various spp.)
Diptera	
Sarcophaga communis Park.	*Culex* sp.
Fannia scalaris Fab.	
Stomoxys calcitrans L.	
Musca domestica L.	
Calliphora vomitoria L.	
Lepidoptera	
	Cirphis unipuncta Haw.
	Agrotis sp.
	Diacrisia virginica Fab.
	Archips sp.

*Species utilized were crepuscular.

The actual experiments were developed upon the premise that the stay of any insect at heights above one kilometer is transient, and the maximum duration of any experimental condition was limited to five hours, so that the assumption of any lethal factor determined by developmental studies was invalidated. The tests were grouped as follows:

I. *Pressure*

(1) The pressure was lowered at varying rates from a surface pressure of 1,000 mb. to a minimum pressure of 50 mb. (= 37.5 mm. = 1.47 inches of mercury), while the temperature was kept constant at +24.0 degrees C.

(2) The temperature was held steady at each of the ten Centigrade-degree intervals between +24.0 and −6.0 degrees C., while the pressure was lowered to 50 mb. at each ten-degree interval.

Pressure experiments (1) and (2) each were carried out at relative humidities of 30, 60 and 80 per cent.

(3) The pressure was lowered and raised rapidly in a small bell jar to simulate the pressure range traversed by vertical currents with speeds well in excess of 26 meters per second. In this experiment, no attempt was made to guard against evaporation from the insect bodies brought about by rapid decreases in pressure.

II. *Temperature*

(1) The temperature was lowered to 0.0 degrees C., while the pressure remained constant at 1,000 mb.

(2) The pressure was held steady at each of the 100-mb. intervals between 1,000 and 400 mb. (7.18 km.), while the temperature was lowered from +24.0 degrees C. to the lowest temperature producing immobility of all specimens at each pressure level.

(3) Temperatures of 0.0, −10.0 and −25.0 degrees C. were established in a cold air cabinet, and the insects were dropped into the cold air directly from

room temperature. The insects were freed from cages to eliminate any form of insulation against the sudden temperature change. They remained in the cabinet in fan-circulated air for periods up to ten minutes after freezing, and then were thawed. Immediately they showed signs of life they were frozen again. This process was repeated five times to simulate temperature ranges traversed by rapidly moving vertical currents.

The above tests were carried out at relative humidities of 30, 60 and 80 per cent.

(4) At temperatures of 0.0, −10.0 and −25.0 degrees C., the insects' bodies

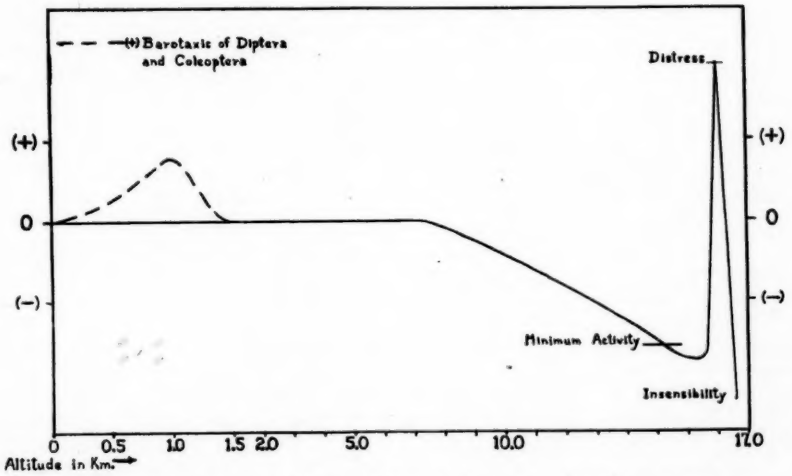

Figure 1.— Variation in insect flight activity with decreasing atmospheric pressure.

were coated with water cooled nearly to the freezing point, and introduced to the cold until frozen as in (3). They were then removed and covered with a second film of water as quickly as possible. This layer in turn was frozen, and so on, up to five such exposures. This experiment simulated repeated freezing and ice accretion under saturated air conditions in the currents within convective cloud.

III. *Relative Humidity*

(1) As noted above, the humidity was varied roughly in the pressure and temperature experiments. The lower humidities were established under low room humidity conditions with the aid of calcium chloride crystals. The higher humidities were either those of the room, or they were maintained in slight excess of these by the exposure of open water surfaces to the air stream.

(2) The effect of relative humidity alone was determined by placing the caged insects in a humidity cabinet in which the moisture content of the enclosed air could be varied between 92 and 25 per cent in approximately 10-per cent steps. This was done by exposing various salts to the air flow. At room temperature and pressure, the insects were exposed to each humidity level for one hour.

RESULTS

I. *Pressure*

(1) The resistance of the insects to reduced pressure over periods of 3-5 hours is such that pressure may be disregarded as even a limiting factor in the aerial distribution of insects. Table II gives the pressure levels and the equivalent heights at which the insects become inactive and at which they become insensible. The homopterous species appear to be less resistant to lowered pressures than do species of other orders. The diurnal Diptera, on the whole, seem to be less resistant than are nocturnal Lepidoptera.

Table II. Pressures and corresponding heights causing inactivity and insensibility in insect test-species.

Species	Pr. in mb. causing inactivity	Equiv. ht. in km.*	Pr. in mb. causing insensibility	Equiv. ht. in km.*
Cicadellidae (averaged)	180	12.46	160	13.21
Ceresa bubalus	180	12.46	150	13.62
Cercopidae (averaged)	120	15.04	100	16.21
Musca domestica	120	15.04	100	16.21
Fannia scalaris	120	15.04	100	16.21
Stomoxys calcitrans	120	15.04	105	15.90
Calliphora vomitoria	115	15.30	105	15.90
Culex sp.	115	15.30	70	18.49
Sarcophaga communis	110	15.60	100	16.21
Archips sp.	110	15.60	100	16.21
Chrysopa sp.	110	15.60	95	16.54
Diacrisia virginica	100	16.21	90	16.88
Cirphis unipuncta	90	16.88	70	18.49
Agrotis sp.	80	17.63	65	18.98
Elateridae (averaged)	75	18.06	60	19.47

*According to the U. S. Standard Atmosphere.

Table II gives the pressures at which the species became inactive and at which they became insensible, as indicated by a loss of footing and collapse without further movement. However, the actual flight activity of the insects varied more subtly, so that a curve expressing the variations in this activity, above and below observed normal surface activity, is included (fig. 1). This curve expresses flight activity as the ordinate, varying above or below a normal "zero" abscissa-line. Along the base of the figure are listed altitudes in kilometers equivalent to the pressures which governed the various degrees of flight activity.

The broken line in the first part of the curve which shows a marked increase in activity here applies only to the Coleoptera and Diptera. It is significant in the light of the results of actual aircraft collections and of surface observations by various authors. Referring to figure 1, it will be seen that, as the pressure decreases, there is a distinct increase in the activity of these insects, up to a height of about 1.46 km. (4788 ft.), where it again approaches normality.

It was thought at first that this increase in activity was due to distress because of decreasing air pressure or oxygen, and that the later return to normal came about through acclimatization. However, the same activity was manifest

within the same pressure range, regardless of the rate of pressure change. The pressure, on occasion, was dropped so slowly as to correspond to height increasing at the rate of one meter per minute. Activity increased even when the pressure was held steady at each ten-meter height interval for ten minutes to give ample time for any necessary acclimatization.

In order to determine whether this activity was brought about by a decrease in the partial pressures of oxygen and carbon dioxide, the following experiment was performed. Flies were placed in a bell jar, and the pressure was lowered to 890 mb. (1.08 km.) This, of course, reduced the amounts of all gases present. Nitrogen was then passed into the bell jar until the air pressure returned to normal. In this way, the oxygen-carbon dioxide content of the air was held at the actual amount present at the reduced pressure, while the total air pressure was raised to the original state. If the decrease in oxygen-carbon dioxide tension had been the cause of the increased activity, the insects should have maintained this activity after being returned to room pressure, since the oxygen-carbon dioxide values were still below normal. In no case did this occur. Hence, it would appear that this increased activity is due to reduced air pressure, and is a barotaxic response. As noted above, this increase in activity at slightly reduced pressures applies to Coleoptera and, especially, to Diptera. Some increases were apparent in the other orders available for experiments, but they were neither so definite nor so consistent as in the two orders mentioned.

Upon its return to normal, the latter part of the activity curve is generalized for all species. It will be seen that, after 8-10 km., flight activity decreases until the minimum flight pressure is passed. This pressure varies with the species, as shown in Table II, but the average curve shows the trend for any of the insects. Below the minimum flight pressure, the insects become quite still, but are still capable of appendage movements. Just prior to the point where an individual loses its footing and becomes motionless or insensible, there is a sudden, frenzied burst of activity, often accompanied by attempted flight in the thin air, which can be interpreted only as extreme distress in the light of subsequent events.

As the pressure is raised slowly, the insects recover at pressures slightly above their minimum activity pressures. Activity is again quite normal by the time the equivalent of 8 km. is reached on the return to surface conditions. Considering the extreme altitudes involved, it is evident that insects may easily withstand air pressures of a far smaller order than can any human.

(2) The resistance to pressure changes was in no way impaired by lowered temperatures or humidities within the time intervals involved. This is one instance where developmental studies are at variance with the present work (2).

(3) All species withstood five rapid pressure drops and returns in the bell jar. This experiment was essentially the same as that performed by Lutz (3) upon muscid flies. Lutz placed water in the bell jar so that evaporation would not kill the insects. In the present work, no water was placed in the bell jar, but there were not as many return pressure trips as in the original experiment of this type.

Heavier-bodied insects, such as *Calliphora vomitoria,* frequently reacted to the immediate rise in pressure by struggling violently for a second and then dropping, apparently lifeless. Recovery was complete within twenty minutes, however, with no observable after-effects. Lighter-bodied insects, such as *Culex* sp., withstood the sudden return of pressure with no apparent adverse reaction. It is obvious that the pressure range traversed by rapid convection would do no harm to an insect born through it, since convective processes certainly do not reach to such high altitudes as the lowest bell jar pressures obtainable, nor is the speed of such processes comparable to the rapid evacuation of a bell jar..

II. *Temperature*

(1) As has been noted in the course of many developmental studies, there arises a zone of decreasing activity as the temperature is lowered toward freezing conditions. Entering this zone, an insect becomes progressively less capable of coordinated movements. The upper limit of the zone appears at fairly high temperatures in the case of most of the diurnal species tested, and usually at lower temperatures for the nocturnal species. Data for some of the test-species appear in Table III. It will be noticed that minimum flight temperatures are given. The method used favoured the finding of the minimum temperature at which flight could be induced. It must not be supposed that normal flight activity is necessarily the rule at these temperatures in the field.

TABLE III. Minimum flight and activity temperatures of test-species.

Species	Minimum flight temperature, deg. C.	Minimum activity temperature, deg. C.
Diurnal spp.		
Musca domestica	+14.0	+ 7.0
Calliphora vomitoria	+10.0	+ 4.0
Sarcophaga communis	+12.0	+ 9.4
Ceresa bubalus	+14.5	+12.7
Nocturnal spp.		
Cicadellidae (averaged)	+13.9	+12.7
Cercopidae (averaged)	+13.9	+12.7
Elateridae (averaged)	+12.2	+10.0
Culex sp., ♂	+ 8.9	+ 5.6
Culex sp., ♀	+ 6.1	+ 5.0
Chrysopa sp.	+ 6.1	+ 4.4
Cirphis unipuncta	+ 2.0	0.0
Diacrisia virginica	+ 1.7	+ 0.6
Agrotis sp.	+ 1.1	+ 0.5

It is evident from Table III that there is a fairly marked sex difference in temperature resistance in *Culex* sp. This was borne out upon the collecting nights for this species, when it became quite difficult or impossible to find any males if the temperature dropped below +18.0, while females were active occasionally at +10.0 degrees C.

It was found that the homopterous species did not stand very low temperatures for any length of time. This was borne out in subsequent tests (2), (3) and (4), in addition to storage tests.

(2) There is some slight evidence to indicate that a decreased pressure had the effect of raising the temperature of minimum activity. In other words, the lower the pressure, the higher the temperature at which the insects became inactive. However, in many cases this rise in temperature was so slight as to cause serious doubts as to its existence, and even in clearer cases it did not amount to an increase of more than a half-degree Centigrade for a 600 mb. drop in pressure.

In the above experiments, a temperature of 0.0 deg. C. had no harmful effect upon any of the species exposed to it at the various humidities for five-hour periods (save the homopterous species mentioned previously).

(3) All but the homopterous species withstood the repeated freezings and thawings at five-minute intervals at 0.0–10.0 and–25.0 deg. C. in the himidity range of 30-80 per cent. At each return to room temperature, complete recovery took from three to five minutes in all cases. Exposures of more than five minutes at subzero temperatures produced some mortalities. *Chrysopa* sp. indi-

viduals usually died if exposed for more than six minutes. Dipterous and lepidopterous species survived eight-minute exposures. Ten minutes or more at subzero temperatures at any one time apparently is fatal to all the species tested.

(4) At zero and subzero temperatures, when the insect bodies were introduced to the cold air bearing a film of water, the chrysopids died within one minute. Other species withstood these conditions as well as in II (3), up to the required five times. The muscid flies seemed to recover particularly well when they were returned to room temperature.

III. *Relative Humidity*

(1) Lowered humidities at low pressures and temperatures had no special effect upon the insects. In near-saturated air at zero and subzero temperatures, the high humidity apparently hastens death for some species, as noted under II (4).

(2) At surface temperatures and pressures, the effect of high or low humidities upon the flight activity of insects may be of significance in the field, but, for the species tested, seems to be of no particular laboratory significance. In the humidity range of 92-25 per cent, there was no appreciable increase or decrease in flight activity over the one-hour periods at each ten-percent level.

DISCUSSION

It is evident that the decrease of atmospheric pressure may be safely neglected as either a limiting or a lethal factor among the elementary environmental changes experienced by insects distributed at higher altitudes.

The marked increase in the flight activity of Diptera and Coleoptera observed within the pressure range between sea level and a height of about 1.5 km. is particularly significant from the standpoint of the actual vertical distribution of these orders.

Glick (1) found that the Diptera, Coleoptera and Hymenoptera were consistently more abundant than insects of other orders in the daytime insect collections between 200-5,000 ft. It might be argued that these orders had a numerical superiority at the surface which rendered them particularly vulnerable to distribution by various mechanical means. However, the aircraft data were collected under all weather conditions, and sheer weight of numbers cannot wholly account for the appearance of these orders in greater numbers at such consistently higher altitudes than any of the other orders collected. It seems evident that there is a definite speeding up of activity in a barotaxic response to slightly lowered pressure.

The variations in insect activity with changing surface pressures have been observed by a number of authors. Underhill (7) observed that certain simuliids fed more readily during rapid falls of pressure, or during low pressures. Parman (5) observed that the numbers of muscid Diptera decreased markedly with the passage of a severe storm, the approach of which was heralded by a rapidly-falling barometer.

Before this storm, the muscids became nervously active, seeking sheltered places where they became comatose. The present writer has observed the same reactions in muscid Diptera before thunderstorms, with some important exceptions. As the pressure falls rapidly, the flies do increase activity, at times appearing frenzied. However, before the storm breaks, not all of the flies take cover. Many are seen circling rapidly quite high in the air as the rain begins. Those which do become comatose in places protected from the rain-squall, but not, of course, from decreasing air pressure, have been observed to recover during the passage of the storm.

It is highly probable that the marked decrease in the numbers of muscids after Parman's storm at Corpus Christi, Tex., was partly due to a redistribution of the aerial population by strong currents of the storm. When one considers the ability of the insects to withstand extremely low pressures, as shown by Lutz

(3) and more fully in the present work, it hardly seems possible that a rapid fall in pressure alone, particularly within the surface pressure-range, would produce either coma or death. The activity of insects in thunderstorms will be discussed at greater length in a subsequent part of this work.

Temperature is the definite limiting factor to any attempt by an insect to reach higher altitudes by its own efforts, since it is obvious that no insect could continue to support itself by flight if it was cooled below its particular minimum flight temperature. Regardless of the specific differences in that temperature, it may be taken for granted that no active flight would extend above the height of the zero isotherm.

If the insect is carried to low temperatures by some strong convective process, the lethal effect of a subzero temperature would seem to depend not so much upon the number of times the inert insect is exposed to it by the moving circulation, but more upon the duration in minutes of any one such exposure, and, also, upon the relative humidity of the air. Insects with relatively hard exoskeletons may easily withstand several freezings under saturated conditions in convective circulation. Soft-bodied insects, such as *Chrysopa* sp., are instantly rendered vulnerable to the cold by saturated air or by deposited surface moisture.

It was found that a number of nocturnal insects have lower minimum flight temperatures than those of the diurnal species. In addition to permitting flight activity close to the surface in the cooler night air, the ability of the nocturnal species to remain active at reduced temperatures would make it possible for these species to reach greater heights under their own power than most diurnal species could attain. Nocturnal species are less likely to be the passive subjects of transport by convective processes, since these processes are of relatively infrequent occurrence during hours of darkness.

In the course of the temperature experiments, it was noticed that any insect cooled below its minimum flight temperature invariably folded its wings in the normal rest position. This folding took place regardless of the rapidity of the drop in temperature. In other words, it was found that no insect could be immobilized in a natural flight attitude at temperatures such as would be experienced up to heights of 4-7 km. This fact is of particular significance in any consideration of the horizontal transport of insects within a zone of low temperature, and will be discussed at greater length in a succeeding part.

Changes in relative humidity ordinarily seem to have slight effect upon the average insect under flight conditions, except in the above-mentioned instance at freezing temperatures when the air is saturated. With certain species, the high humidity may then be considered as the factor releasing the lethal effect of the low temperature.

Some evidence of sex differences in resistance (particularly to temperature) was found, but this is to be expected in the light of much material available from other field studies.

It seemed of interest to determine whether an insect might survive exposure to all such conditions outlined in the description of the experimental methods, and yet be rendered sterile by them. Lutz (3) was able to obtain fertile eggs from a pair of flies after exposing them to low pressure. In the present work with field-collected adults, it is of interest to note that a female *Calliphora vomitoria* deposited ova after exposure to all the test conditions, and that a female *Diacrisia virginica* deposited 180 eggs after being exposed to all conditions and then stored at freezing temperature for another twenty-four hours. These particular eggs were deposited at 0.0 degrees C. (Moran and Lyle (4) noted oviposition by *Cirphis unipuncta* in Mississippi at temperatures below freezing). In each of the above cases, larvae emerged from the eggs in due course. These were the only gravid females obtained from the field, but they serve as an indication of the possibilities of species distribution after exposure to upper air conditions.

It is evident that the great changes experienced by insects distributed actively or passively through the upper air have, in most cases, no apparent lethal or sterilizing effect. Although low temperature acts as a limiting factor to flight, the passive population of the convective zone is not likely to be injured or killed by large decreases in temperature, since the time of exposure to any given temperature is of such short duration. Soft-bodied Homoptera and Neuroptera are likely to be killed by low temperatures, providing their times of activity coincide with atmospheric processes capable of transporting them to the required level. Most insects, however, seem capable of withstanding any environmental conditions to which they might be exposed for a time interval of reasonable duration.

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DESCRIPTIONS OF THREE NEW SPECIES OF *DACTYLOPSYLLA* JORDAN AND ONE NEW SUBSPECIES OF *FOXELLA* WAGNER, WITH RECORDS OF OTHER SPECIES IN THE GENERA (SIPHONAPTERA)

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In the course of investigating the distribution of plague in the western part of the United States, the field units of the U. S. Public Health Service have collected several species of the genera *Dactylopsylla* and *Foxella*. Among these collections there are three new species of *Dactylopsylla* and one new subspecies of *Foxella* whose characteristics are as follows:

Dactylopsylla neomexicana n. sp.

This species is close to *Dactylopsylla bluei* (C. Fox).

Male and female: Frontal tubercle small. Eyes absent. Preantennal region of head with 2 rows of bristles; ocular row with 5 to 7 bristles and upper row of 7 to 10 bristles. Postantennal region of head with numerous short spine-like bristles along antennal groove and a marginal row of 6 or 7 bristles on each side. Labial palpus five-jointed and extending approximately three-fourths the length of the fore coxae. Pronotal ctenidium of 21 spines. Apical spines on the metanotum, 1, on the abdominal tergites, in male, I, II and III, 1, in the female, I and II 1, on each side. There are 3 or 4 large dark spine-like bristles on the border of the posterior apical sinus of the mid and hind coxae.

Modified segments: *female*. Antepygidial bristles 3. Head of receptaculum seminis well pigmented, slightly longer than broad. Tail of receptaculum seminis shorter than head, broadest near apex, tip well sclerified, but

*From the Plague Investigation Station, San Francisco, California.

not prominent. Sternite VII varies as illustrated (fig. 2). Tergite VIII concave on posterior border and armed with 40 to 50 bristles from stigma down. Stylet with an apical and 2 lateral bristles.

Modified Segments: *male.* Antepygidial bristles, 1 long well developed and 1 short undeveloped. Manubrium broad with apex curving upwards. Immovable process (P) of clasper short, broad, evenly rounded at apex and bears 3 to 5 bristles. The movable finger (F) of the clasper long, curving distad and acuminate. In general, the finger has the appearance of a walking stick. The finger has an apical bristle and 3 bristles on the posterior border. Sternite VIII concave on the dorsal apical half and armed with 4 large bristles on ventral border, uppermost bristle apical. The internal portion of sternite IX expanded at apex. Anterior lobe of external portion of sternite IX long and bears numerous small pale bristles; the upper lobe with posterior border convex and anterior border concave; there are several small bristles scattered over the upper lobe (fig. 1).

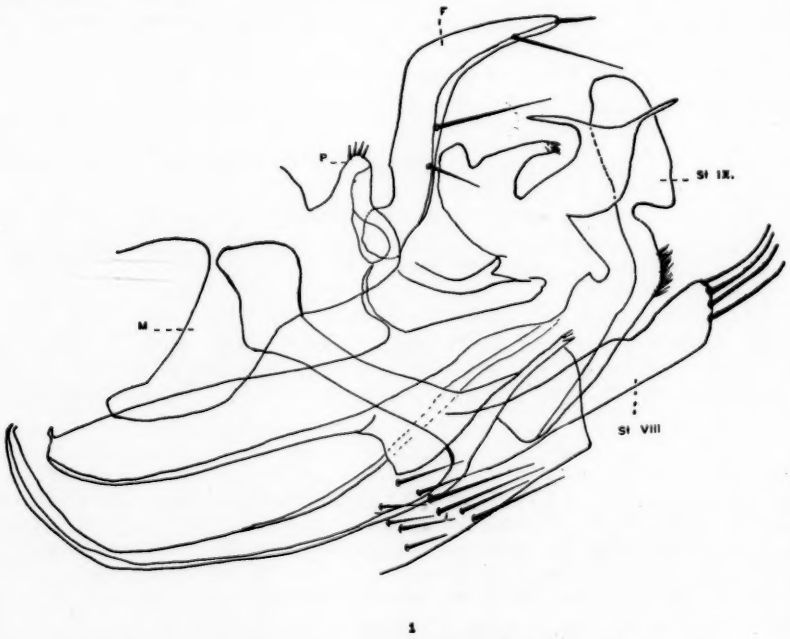

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Fig. 1. Modified segments of *D. neomexicana* male. *M*, manubrium; *P*, immovable process of clasper; *F*, movable process or finger of clasper; *St*, sternite.

Length: *female*, 3.30 to 4.05 mm., average 3.69 mm. *Male*, 3.00 to 3.22 mm., average 3.15 mm.

Type locality: San Miguel County, New Mexico.

Type host: *Thomomys fulvus.*

The *holotype* male, the *allotype* female, 2 female and 5 male *paratypes* were collected 20 miles south of Las Vegas, San Miguel County, New Mexico, May 28, 1943.

The holotype and allotype are deposited in the collection of the U. S. Public Health Service Plague Investigation Station, San Francisco, California. Paratypes are deposited in the U. S. National Museum, Washington, D. C. and Pacific University, Forest Grove, Oregon.

Dactylopsylla monticola n. sp.

This species is also close to *Dactylopsylla bluei* and is known only from 2 female specimens.

Female: Frontal tubercle very small. Eyes absent. Preantennal region of head with an ocular row of 4 bristles, upper row of 6 bristles, several minute setae scattered over the region and 1 large bristle at the outer genal margin. Postantennal region of head with 1 large bristle, a row of minute bristles along the antennal groove and a posterior row of 6 bristles on each side. Labial palpus five-jointed and extending to the apex of fore coxae.

Pronotal ctenidium of 22 spines. Apical spines on metanotum, 1 on each side; tergites I and II have 2 apical spines on each side.

Modified segments: Antepygidial bristles, 3, median one long. Head of receptaculum seminis (Rs) semiglobular, the ventral border almost straight, the dorsal border convex. Tail of receptaculum seminis equals length of head, with large sclerotized tip. Sternite VII without sinus and bears 23 or 24 bristles on each side (fig. 7). Tergite VIII concave, with upper lobe acute. Stylet approximately three times as long as broad and bears an apical and 3 lateral bristles.

Length: 2.55 to 3.60 mm., average 3.07 mm.

Type locality: Ormsby County, Nevada.

Type host: *Thomomys monticola.*

The *holotype* female and 1 female *paratype* were collected 13 miles west of Carson City, Ormsby County, Nevada, August 19, 1937 on *Thomomys monticola.*

The holotype is deposited in the collection of the U. S. Public Health Service Plague Investigation Station, San Francisco, California. The paratype female is deposited in the U. S. National Museum, Washington, D. C.

Dactylopsylla (Foxelloides) nuditenacula n. sp.

This species is close to *D.* (*F.*) *bottaceps* Hubbard.

Female: Frontal tubercule small. Eyes absent. Preantennal region with an ocular row of 3 and an upper row of 5 bristles. Postantennal region with a row of minute bristles along antennal groove and a large bristle above this row, in addition to a posterior row of 6 bristles. Labial palpi five-jointed and extending to apex of fore coxae.

Pronotal ctenidium of 22 spines. Apical spines on metanotum and abdominal tergites I and II, 1 on each side.

Modified segments: Antepygidial bristles 3 on each side. Sternite VII and receptaculum seminis as illustrated (fig. 3). Sternite VII bears 17 bristles on each side. Tergite VIII concave on posterior border. Stylet three times as long as broad and bears an apical and two lateral bristles.

Male: Ocular row of 3 and upper row of 4 bristles. Labial palpi barely reaching apex of fore coxae. Other characters of head same as in female.

Apical spines on metanotum 3; abdominal tergites I and III, 1; II, 2 on each side.

Modified segments: Antepygidial bristles 3 on each side. Movable finger (F) of clasper long, almost of equal width throughout and the posterior margin without bristles. Immovable process (P) of clasper short, evenly rounded at apex and bears 3 pale bristles. Sternite VIII broad at base, apex pointed, dorsal border concave, ventral border convex and bears 5 pale bristles, one nearest apex largest. Proximal lobe of sternite IX bears 7 pale bristles; distal lobe with minute bristles scattered over entire lobe (fig. 4).

Length: female, 3.91 mm.; male, 3.89 mm.

Type locality: Gallatin County, Montana.

Type host: Probably *Thomomys* (type material from *Mustela arizonensis.* The only specimens known are the *holotype* male and *allotype* female

collected 9 miles northwest of West Yellowstone, May 24, 1938. The holotype and allotype are deposited in the collection of the U. S. Public Health Service Plague Investigation Station, San Francisco, California.

Foxella ignota omissa n. subsp.

This subspecies is close to *F. i. recula* (Jordan and Rothschild) but differs in the modified segments.

Female: The posterior border of sternite VII only slightly incurved and the postero-ventral point more acuminate; the sternite bears 17 to 20 bristles on each side. The tail of receptaculum seminis longer and tip more sclerified than in *recula* (fig. 5).

Male: The immovable process (P) of clasper much shorter and broader. The movable finger (F) of the clasper is broader at its base and gradually tapering to apex, with little or no incurve on posterior border; it is armed with 3 or 4 pale bristles. Tergite VIII bears 25 to 28 bristles from the stigma downward. Sternite VIII is longer from base to apex and bears 4 or 5 small bristles in addition to an apical bristle which is smaller than in *F. i. recula;* from the apical bristle to the apex of sternite VIII the distance is twice as great and the apex more acuminate than *F. i. recula.* The manubrium is broader and less acuminate (fig. 6).

Length: *male,* average 2.41 mm., *female,* average 2.92 mm.

Type host: Probably *Thomomys* (the types were collected from *Mustela arizonensis*).

Type locality: Coconino County, Arizona.

The *holotype* male, the *allotype* female and 7 male and 5 female *paratypes* were collected 1 mile west of Cosnino, Coconino County, Arizona, from *Mustela arizonensis,* April 25, 1938.

The holotype and allotype are deposited in the collection of the U. S. Public Health Service Plague Investigation Station, San Francisco, California. Paratypes are deposited in the U. S. National Museum, Washington, D. C.

Note: The exact location in Apache Co., Arizona, from which the mutilated female type specimen of *F. i. apachina* (C. Fox) was collected is not known. Jordan and Rothschild (Ecto. 1 (1), p. 56, 1915) redescribed and illustrated the subspecies from specimens collected at Hermosa, Colorado, and other points in that state. The U. S. Public Health Service collection contains a series of both sexes of the subspecies, collected at Marvel, Colorado, which is a short distance south of Hermosa, Colorado. Hubbard's illustrations of *D.* (*F.*) *i. apachina* (Pac. Univ. Bul. 40 (2), 1943) do not correspond with our specimens of *apachina* nor do they appear to fit the redescription by Jordan and Rothschild. Hubbard's illustrations appear to coincide with our material described above as *F. i. omissa.*

ADDITIONAL RECORDS FOR THE GENERA *DACTYLOPSYLLA* AND *FOXELLA*

Dactylopsylla bluei (C. Fox)

California: Hunter-Liggett Military Reservation, Monterey Co., 2 males collected May, 1942, and March, 1943, on *Thomomys bottae,* and 1 male collected April, 1942, on *Citellus beecheyi.*

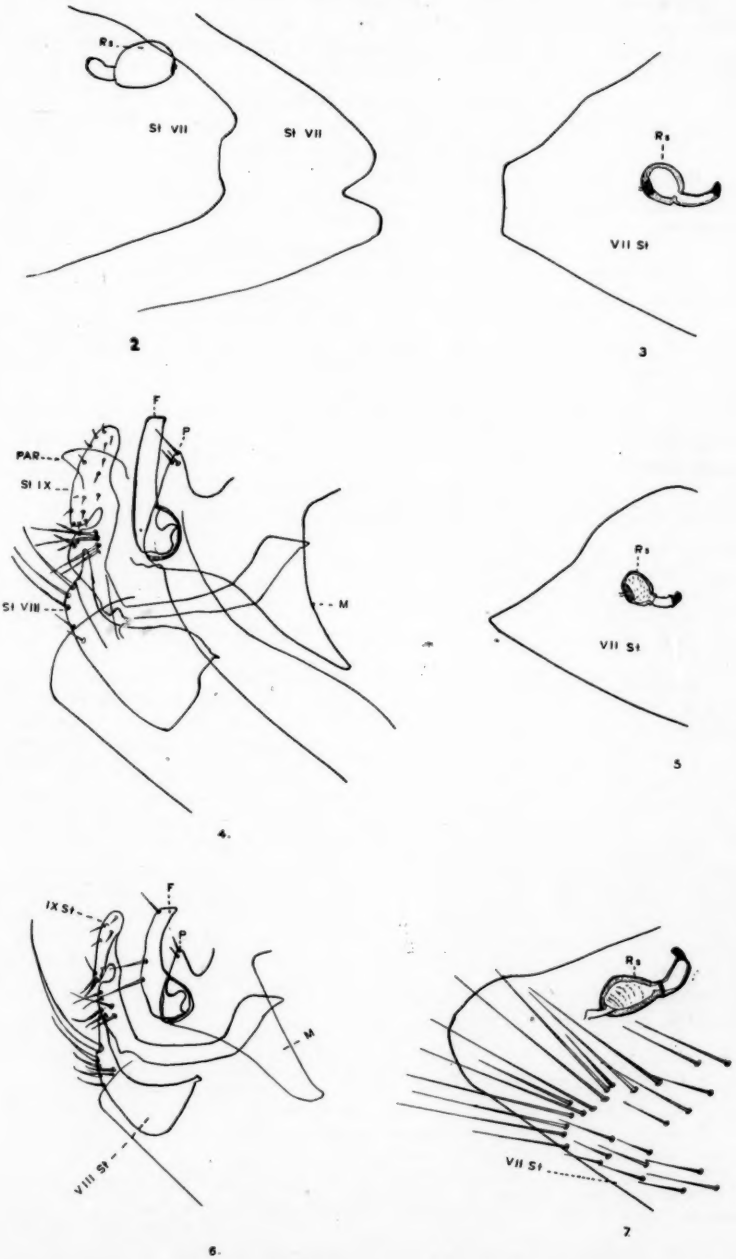
Foxella ignota albertensis (J. & R.)

Montana: Fergus Co., 1 female and 1 male collected August, 1939, on *Mustela arizonensis.*

North Dakota: Ward Co., 2 females and 2 males collected July, 1942, on *Mustela longicauda.*

Wyoming: Albany Co., 1 female and 1 male collected August, 1942, on *Onychomys leucogaster*; Crook Co., 1 female and 1 male collected August, 1943, on *Mustela arizonensis*; Laramie Co., 4 females and 3 males collected June, 1943, on *Mustela sp.*

PLATE I.



NEW SPECIES AND SUBSPECIES OF *DACTYLOPSYLLA* AND *FOXELLA*

Foxella ignota apachina (C. Fox)

Colorado: Gunnison Co., 1 female and 1 male collected August, 1937, on *Mustela* sp.; La Plata Co., 3 females and 3 males collected June, 1939, on *Thomomys fossor*; San Miguel Co., 6 females and 5 males collected July, 1939, on *Mustela arizonensis*.

Foxella ignota coufferi Augustson

Arizona: Mohave Co., 1 male collected April, 1938, on *Thomomys* sp.

Foxella ignota ignota (Baker)

Kansas: Finney Co., 1 female collected May, 1942, on *Dipodomys ordii*.

Nebraska: Grant Co., 2 females collected October, 1942, on *Onychomys leucogaster*.

Foxella ignota recula (J. & R.)

Idaho: Latah Co., 1 male collected May, 1937, on *Thomomys* sp.; Lewis Co., 1 female collected August, 1936, on *Citellus columbianus*.

Oregon: Harney Co., 2 females and 2 males collected July, 1937, on *Mustela* sp.; Union Co., 1 male collected April, 1940, on *Mustela* sp.; Wallowa Co., 2 females collected July, 1937, and March, 1939, on *Citellus beldingi oregonus*.

Washington: Columbia Co., 2 females and 1 male collected May, 1942, on *Mustela frenata*; Spokane Co., 1 female and 1 male collected April, 1942, on *Mustela frenata*.

Foxella ignota utahensis Wagner

Colorado: Moffat Co., 15 females and 11 males collected July, 1938, on *Mustela arizonensis*.

Idaho: Clark Co., 2 males collected May, 1937, on *Thomomys* sp.; Bear Lake Co., 1 female collected April, 1938, on *Citellus armatus*; Fremont Co., 1 female collected June, 1938, on *Mustela arizonensis*; Teton Co., 2 females collected July, 1937, on *Mustela* sp. and 1 female collected June, 1939, on *Citellus armatus*.

Montana: Gallatin Co., 1 female collected May, 1938, on *Thomomys* sp.; Park Co., 1 male collected July, 1938, on *Citellus armatus* and 1 male collected July, 1939, on *Mustela arizonensis*.

Utah: Duchesne Co., 2 females and 2 males collected May, 1937, on field mice (*Microtus*); Salt Lake Co., 1 female collected April, 1937, on *Thomomys* sp.; San Pete Co., 1 female and 1 male collected May, 1939, on *Thomomys fossor*; Uintah Co., 1 female and 2 males collected August, 1938, on *Mustela arizonensis*.

Wyoming: Big Horn Co., 1 male collected June, 1940, on *Onychomys leucogaster*; Carbon Co., 2 females collected July, 1937, on *Mustela longicauda*; Lincoln Co., 2 females on *Thomomys* sp.; 1 female on *Citellus armatus* and 1 female and 1 male on *Mustela arizonensis*, all collected June, 1938; Sweetwater Co., 8 females and 9 males collected August, 1938, on *Mustela* sp.; Teton Co., 3 females and 1 male collected August, 1937, on *Mustela longicauda* and 1 female and 1 male collected August, 1938, on *Mustela arizonensis*; Uinta Co., 1 male collected July, 1938, on *Citellus richardsoni elegans*.

EXPLANATION OF PLATE I.

2. Sternite VII and receptaculum seminis of *D. neomexicana* female.
3. Sternite VII and receptaculum seminis of *D.* (*F.*) *nuditenacula* female.
4. Modified segments of *D.* (*F.*) *nuditenacula* male.
5. Sternite VII and receptaculum seminis of *F. i. omissa* female.
6. Modified segments of *F. i. omissa* male.
7. Sternite VII and receptaculum seminis of *D. monticola* female.

Rs, receptaculum seminis; *M*, manubrium; *P*, immovable process of clasper; *F*, movable process or finger of clasper; *Par*, paramere; *St*, sternite.

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